Sociology Compass 2/6 (2008): 1878–1895, 10.1111/j.1751-9020.2008.00147.x

The Sociology of the Future: Tracing Stories of Technology and Time

Cynthia Selin*
Center for Nanotechnology in Society & the Consortium for Science, Policy and Outcomes, Arizona State University

Abstract

The sociology of the future is an emerging field of inquiry that works to understand future consciousness drawing from a mix of Science & Technology Studies and the practice of foresight. Through an exploration of the theories, methodologies, and quagmires of anticipation employed in the study of nanotechnology, this piece introduces the sociology of the future and suggests some ways the field is taking definition. Exploring the future tense provides a means of taking responsibility for what is to come; yet, the movement of the social sciences into the tricky terrain of the future presents tensions. Understanding plausibility, how different communities use anticipatory knowledge, and the performative role of expectations in innovation remain areas of research rich with dilemmas and delights. As social scientists begin to weave their own accounts of futures, they should pay attention to the politics of such rendering.

Extension of the technological reach

Scholarly attention to the development of new technologies and to exploring the sociologic tools and methods we have for grasping their emergence is exceedingly important not only for the dual nature of technology as blessing and curse, but also because our technological reach into the future is growing. Our ability to produce technologies that have a lasting impact on social systems seems to be growing given the biological, chemical, and material technologies of late. Nanotechnology is one such novel technology area that is regularly promised to radically alter what it means to be human, our systems of production, and our environmental landscapes.

Whether expectations of seamless interactions with nature, non-polluting instantaneous production, or unprecedented wealth and health, nanotechnology is presented by promoters as the elixir for post-industrial ills (Drexler 1986; Roco and Brainbridge 2001; Wood et al. 2003). Yet, this brazen optimism is also balanced by visions of self-replicating nanobots out of control and more tempered analyses about nanotechnology's ability to

produce particles with unknown toxicity (Oberdörster 2004), unintended consequences (Mnyusiwalla et al. 2003; Tenner 2001), shifts in privacy and security (MacDonald 2004), and greater inequalities (ETC group 2003; Meridian Institute 2005). There is no shortage of imagination speculating about the potentials of nanotechnology. Future consciousness is put to work developing scenarios of nanotechnology and negotiating visions of the future.

Technologies not only intervene in present realities, they also create future realities, both symbolically and materially. The rhetoric that surrounds nanotechnology produces imagined futures, while concrete technological practices have the power to produce very real futures materially. Moreover, the rhetorical construction of future worlds directly (and indirectly) influences which technologies are brought into existence by, for example, providing justifications for funding, rallying public support, instigating policy directives, etc. The rhetoric supporting new technologies derives legitimacy from the expertise of those making the claims yet also from the widespread belief in the determinacy of scientific and technological progress.

Whether as autonomous intelligent robots, new forms of bacterial life, photovoltaic material, or molecular manufacturing, the technologies included under the rubric nanotechnology promise to alter the way we work, love and die. Yet, this promise of progress seems to forget the social dimension of technology. As society adopts, rejects, uses, and modifies such technologies, it is likely that power relations will shift, new social identities will emerge, and the meaning of inequality will change. So while the actual production of new technologies may affect the contours of the future, technologies develop in tandem with society's production of meaning.

This ability to not only imagine technologies but also produce technological futures is not matched by our scholarly – or practical – understanding of what kind of socio-technical systems we are creating. Grasping complexity over the long term and accounting for the ongoing myriad of interactions between values, machines, and regimes has proven daunting for the social sciences. Technological knowledge itself is often shrouded in uncertainties and at the same time supported by a hitherto unprecedented speed of development. Quite simply, processes of discovery and invention in the natural sciences and the translation of such knowledge into commodities are faster than our ability to safely regulate or make sense of the new social dynamics engendered by such processes. The wild west of nanoscale science is not matched by the social systems meant to conscientiously guide such developments. The US patent system is overwhelmed dealing with the pace and interdisciplinarity of nanotechnology. Regulatory bodies such as the Environmental Protection Agency are slow to the extent that industry giants such as Dupont are initiating regulatory frameworks themselves (Dupont 2005). Other government agencies are sluggish such that the City of Berkeley took matters into their own hands

by passing a regulation for nanoparticle handling in 2006 (City of Berkeley 2008). The problem of pacing of social and technical systems stresses our ability to act responsibly in the present on behalf of future generations.

These problems of speed and uncertainty are meant to be addressed through practices of foresight (Grupp and Lindstone 1999; Irvine and Martin 1984; Tsoukas and Sheperd 2004). As methodologies born from future studies (Bell 1997), technology assessment (Rip et al. 1995), and strategic planning (Van der Heijden 2004; Wack 1984), foresight practitioners are interested in indicators of the future, or what I call anticipatory knowledge. Anticipatory knowledge adds the temporal dimension to knowledge forms and practices and brings to the fore the transient, locally defined, and multiple nature of knowledge.

A representative definition of foresight is offered by Chia as a: 'refined sensitivity for detecting and disclosing invisible, inarticulate or unconscious societal motives, aspirations, and preferences and of articulating them in such a way as to create novel opportunities hitherto unthought and hence unavailable to a society or organization' (2004, 22). The common thread between the perspectives and professional practices of foresight is the notion that the future is not fully set, but is an object of creation and therefore subject to modulation.

Foresight is a means to analyze the explicit and implicit stories embraced and circulated to cope with futures known and unknown. By 'stories', I highlight from a postmodernist perspective, the difficulties about talking about a world of forces 'out there'. Instead, tacitly understood interpretative frameworks are organized into stories that characterize experience and perceptions. Foresight practices bring these stories out into the open for examination. Such stories of the future are potent sources of legitimization, inspiration, and construction in an emerging technoscience like nanotechnology (Selin 2006). Foresight methodologies are commonly employed in European science policy yet in the US manifest primarily as scenario planning in the corporate sector.

In parallel to foresight, there is renewed interest in the future from the social sciences, particularly within Science and Technology Studies (Hackett et al. 2007; Jasanoff et al. 1995). As governments around the world incorporate studies into the ethical, legal, and social implications (ELSI) into their funding apparatus for nanotechnology, social scientists are being prodded to develop new methodological tools and theoretical understandings that can cope with uncertainty, complexity, and potential (Barben et al. 2007; Macnaughten et al. 2005). Whether donned as constructive technology assessment (Rip et al. 1995), real-time technology assessment (Guston and Sarewitz 2002), or ELSI research, such projects have aims to study the future in order to make better choices in the present.

While there is some exchange between foresight practitioners and social science scholars of technology, they reside in distinct fields of inquiry. This piece is meant to put into dialogue Science and Technology Studies (STS)

with foresight, a project that has some early beginnings in a movement in Europe to develop the sociology of expectations (Brown and Michael 2003; Brown et al. 2000). In doing so, this paper points out the shared assumptions and key differences in their approach to the future. By covering the social science research on the development of nanotechnology and particularly focusing on the way the future has become an object of study, issues of legitimacy and power and the role of the scholar become important.

Some of the more fascinating questions begging attention by scholars interested in STS and the sociology of the expectations are:

- How are visions of the future influencing technological development?
- What role does 'potential' have in the constitution of this new ubiquitous domain of nanotechnology?
- How are such futuristic stories legitimated and with what effects?
- In what ways can the future be employed to encourage responsible governance in the face of uncertainty?
- What are the risks for the social sciences in trespassing into the future tense?

This article is designed to sort through such tensions of the future tense and describes some of the theories and methods that investigate the future in order to better understand today. The amalgamation of these different theoretical and methodological perspectives begins to develop what can best be called the sociology of the future.[1]

Theories: momentum and the surprise of emerging technologies

Much of the discussions about the nanoscale suppose technologies that are seriously novel, suggesting that the past is not a guide to the future. This is not to propose that historical experiences with new technologies are not of value, but that extrapolating the past to understand the future may be of limited utility. While we inevitably rely on the past to understand the future, the question is whether we extrapolate in ways that are sufficiently (or excessively) imaginative, robust, and diverse. The call for the social science to study nanotechnology is not one of narrowly predicting social outcomes, but rather of preparedness, prudence, and forethought in the face of complex socio-technical change. The call involves rethinking the role of historical analysis in light of rapid innovation, fundamentally new technologies, and the slowness of our governance mechanisms. If the past is not a guide, and the present is volatile, then how can scholars go about looking to the future?

Uncertainty haunts every turn in the road towards progress as innovation is increasingly complex, interconnected, and fast. Coming to terms with uncertainty is said to be the supreme challenge of our times (Beck 1992).

Yet, the traditional theories and methods of the social sciences are seriously compromised in our efforts to come to terms with obduracy, what stays the same, and with the acting on existing knowledge. Understanding and acting on both emerging (uncertainties) and known knowledge (certainties) is at least as challenging as coping with what we don't know (and what we don't know we don't know).

Historically, the social sciences shy away from studying *lack* of knowledge by giving primacy to evidence-based science, which is tied up to the imperative for proof. The future – whether composed of certainties or uncertainties or the inevitable combination of the two – lies outside the realm of proof. Tools for establishing truth – though also seriously contested – remain the trusted friends of sociology. Without a means to predict behavior, outcomes, or consequences, evidence-based social science is handicapped to investigate uncertainty as an object of study and is instead limited to exploring individuals and institutions stated relationship to uncertainty. That is, sociologic tools readily equip scholars to look at the future in terms of how various people today talk about tomorrow; but they do not enable taking the social reality of futures seriously. As Adam puts it, we are comfortable studying past and present futures, but not future futures (Adam 2006). Conducting inquiries *at* the future confronts social scientists with not only problems of methods and methodology, but also problems of developing theories that move and can account for change processes. There is a shortage of scholarship that can navigate volatile discourses tangled in temporality.

Yet, examining the future as a component of social reality has sporadically been undertaken within the social sciences. Sarewitz et al. (2000) developed a collection about the role of predication in the environmental sciences; Dublin's work (1991) is an inspection of prophesy in political science; and as aforementioned, Adam's work on time and social theory (2000, 2005, 2006; Adam and Groves 2007) goes the distance in exploring futurity in society. Yet, by far the most advanced thinking about the future has come from the highly disparaged field of future studies. Despite Yale University's Bell (1997) and Slaughter's rigor (1998, 2005), there are scant future studies courses offered in university settings and still fewer degrees are offered. Notwithstanding this educational void, futures oriented practices – notably scenario planning – are regularly practiced in a variety of institutional settings. Scenarios are common in commercial and policy settings to the extent that Ringland (1998) suggests that more than 40% of fortune 500 companies have experience with scenario planning. Over the last decade, most European countries have conducted national foresight exercises. As a business practice, scenario planning is one of the longest lasting tools outliving decades of new fangled strategy tools (Sharpe and van der Heijden 2007).

STS is not entirely new in dealing with futures, yet has a different sort of past that has largely dealt with technological change through studies of

expertise (who says which future) and the production of new knowledge (creating futures). STS has also housed much of the research on technology assessment, which often has a future-oriented gaze. As an interdisciplinary study that has appeared over the last three decades, STS maintains methodological promiscuity and divergent theoretical stances yet nonetheless is bound by some basic tenets that prime it well to approach anticipation, visions, expectations, scenarios, and the other creatures of the future tense.

First is a denial of technological determinism (Bijker 1994; Bijker et al. 1987). Most STS scholars assert that there is a not a wave of technology sweeping over humanity which structures our existence completely. While no modern person would deny the profound impacts of the railroad, vaccines, or IT, STS draw attention to how social values impinge on the invention, development, implementation, and adoption of such technological systems. However, interestingly enough, STS scholars also leave room for semblances of determinism in interesting – and controversial – ways (Smith and Marx 1994; Winner 1977).

STS scholars have critically noted that while the early stages of technological development are flexible and subject to improvisation and change, the later stages of technological adoption tend to freeze and make rigid the socio-technical network relations. Economists have long noted this 'lock-in' phenomenon. Lock-in and momentum do not imply absolutes, but rather suggest a stickiness of knowledge and practice that make certain trajectories more obdurate. The term 'emerging irreversibilities' has been summoned to talk about these hardened paths of technological development where alliances, inventions, and agreements lead to inertia such that reversals are unlikely (van Merkerk and van Lente 2005). This hardness has not only to do with the way that new technologies become entrenched in human and social systems as they emerge, but also with the way that new technologies become embedded within existing technological systems and their associated systems of values, institutional norms and historical frames. That is, when dealing with momentum, we have one step into the future and one firmly in the past.

Through this balancing of an open and closed future, STS scholars and foresight practitioners have much in common. Seeing that the future is not completely indeterminate has lead Rip and te Kulve (2008) to point to 'endogenous futures' in sociotechnical systems and scenario planner Wack (1984) to talk of 'predetermined elements'. Both suggest that the future is not wide open but always already structured in important ways thus creating a common conceptual link between the two temporal domains.

Another key linkage between the fields has to do with acknowledging the work that expectations do in the development of a new technological field. Given the focus on the social dimensions of technological development, STS scholars have ably produced evidence of how the vision of the inventor, scientist, or engineer is crucial to the success of the technology (e.g. Carlson and Gorman's 1992 work on Edison). Akrich's work (1992) on

'scripts' identifies how technologies are designed with particular 'programs of action' that constrain or demand specific uses – including future use (1992). In this way, the scripts attending a technology somewhat predetermine action. Fujimura's work (2003) on 'future imaginaries' showed how scientists employ visions of the future to mobilize support for their work.

While some of the earliest references to technological expectations dates back to Rosenberg's 1976 work on the role of expectations in the innovation process, further back, Merton (1948) dealt with self-fulfilling prophesies which can be seen as a precursor to attempts to understand the endurance and performance of expectations. In recent years, the sociology of expectations (Brown and Michael 2003; Brown et al. 2000) has struck the European research scene. Their work has advanced and sophisticated understandings of the role of expectations from an STS perspective.

The impetus of this research agenda is the enduring work of van Lente (1993), who construes expectations as 'forceful fictions' and shows how expectations are implicated in innovation processes and crucial for agenda building. His work has since been developed to provide analytic coverage of how actors become bound to expectations in membrane technology (van Lente and Rip 1998) and has been followed by work on, for instance, reproductive technologies (Bloomfield and Vurdubakis 1995), pharmaceuticals (Hedgecoe and Martin 2003), nanotechnology (Selin 2007), and lab-on-a-chip technologies (van Merkerk and van Lente 2005).

Expectation scholars have also theorized about alternating hype-disappointment cycles (Brown and Michael 2003; Geels and Smit 2000), which have also been studied as hot and cool phases (Callon 1995) both of which work to theorize transitions in technological regimes. Geels and Smit (2000) have also shown how expectations create the momentum and resources to form protective niches, or protected spaces (Rip 2005), which serve to create space for new technologies to emerge when entrenched technologies are dominating.

The thrust of these studies is a demonstration of the work that is performed by stories of the future. Without proof of concept, prototypes, or hard results, emerging technologies rely on promising stories to garner support in the early stages. These stories provide new cognitive frames from which actors in technological regimes perform the tasks of making new technologies, including for instance, forming collaborations, crafting experiments, supporting legislation, or marketing products. Expectations legitimate a new technology, but as we shall see, not without troubles.

In future studies and foresight, many similar concepts about the role of the future abound. The entire practice of foresight is premised on the idea that perspectives on the future have consequence. Wack, arguably the founding father of scenario planning, wrote:

> in times of rapid change and increased complexity ... the manager's mental model becomes a dangerously mixed bag: enormously rich detail and deep understanding that can coexist with dubious assumptions, selective inattention to alternative ways of interpreting evidence, and illusionary projections. In these times, the scenario approach has leverage to make a difference (Wack 1984, 150).

This 'difference' that he states implies that through reinterpreting the future, one can make better decisions in the present. As all decisions are predicated on an image of the future, articulating the vision and subjecting it to scrutiny is seen to impact the bottom line. A decision maker's view of the future can be a 'dangerous' blinding handicap or valuable resource. Foresight practitioners and STS scholars take seriously the role of the future in the present.

Both STS scholars and foresight practitioners hold several assumptions in common: uncertainty problematizes decision making in the present; the future is not totally determined; and what is said about the future matters greatly. In approaching nanotechnology, however, they often employ different methods and have substantially different concerns. In seeking to understand and modulate expectations, in conducting future oriented analysis, and in thinking about desirable futures, STS scholars and foresight practitioners are also confronted with different roles and responsibilities that affect their handling of the future.

Methods: thorny trespasses into the future

Before visions of nanotechnology become a reality (or not), they are resolved as expectations or representations of the not-yet, of uncertainty, of Adam's 'immaterial real' (Adam 2004a,b). By immaterial real, Adam insists that, even though the futures produced (e.g. as stories) and traded (e.g. as promises) do not currently exist, the process of their making actually, really, grants them some sort of ontological status. Stengers (2000) similarly writes of 'vectors of becoming' where the production of knowledge is simultaneously a production of existence. These notions give rise to the importance of rhetoric in the material construction of reality – past, present, and future – and provide a justification for thinking about the future. This too is one way to conceptually overcome the problem of realism in the study of the future: the future is real in so far as the things, deeds, and words today are locked in on creating particular futures. What to do with this state of affairs and how to approach the future in a methodologically sound and consistent way is another matter.

One can study empirically the things (prototypes, strategic plans, design sketches); deeds (investment decisions, educational programs, chemical processes; like pollution); or words (science fiction, after dinner speeches, political promises) to get at the future. Each category has its own problems. What is the prototype if it is dramatically altered in the course of

actual production? What is a description of the allocation of funds if what is funded was simply re-described to qualify for funding? How to get at the actual effect of an after dinner speech such as Feynman's (1959) which has been reified as the origins of and inspiration for nanotechnology? A historical analysis can always yield a trend – a coherent story of change – yet extrapolating the past to create a coherent story into the future assumes that the future will look like the past.

What is more difficult to study is future change over time, a kind of real time, shift-able mapping of things, deeds, and words. Processes of becoming are hard to grasp; yet, foresight methodologies are oriented towards trying to capture future change or at least develop sensitivity to changing circumstances. Through analyzing trends, organizing inclusive dialogue, or modeling complex behavior, the methods grouped under the rubric foresight are unusually concerned with the ways and means of the future.

The methods collapsed as 'foresight' are varied. There are two fundamentally different approaches to studying futures – those that rely on prediction and those that don't. If your goal is prediction, methods such as roadmapping, forecasting, modelling, and predication markets suit you best. If you see contingency and indeterminacy as characterizing your subject, then the qualitative methods of scenarios and horizon scanning may be more appropriate.

These methods are quite different from the methods in STS that rely on more traditional social science tools of interviewing, ethnographic immersion, surveys, focus groups, and the scouring of source material. Losch's (2006) investigations into nanotechnology's futuristic visions argue for discourse theory a la Luhman to crystallize the distributed nature of 'the future' as a means of communication. Hayles' (2004) collection draws on literary theory where Milburn (2004) focuses on science fiction. Berne (2006) has interestingly addressed the moral vision of nanotechnologies practitioners through extensive interviewing. Each of these perspectives provides its own prescription for what to do analytically with the future (e.g. trace agency, identify communicative pathways, employ a cultural critique, etc.).

In both domains – foresight and STS – there is the methodological issue as to whose future matters. In technology assessment, for instance, there are expert driven reports and there are efforts to involve assorted publics in decision making. The decision to be inclusive or expert based is one that has significant effects on the outcomes of the assessment for all the obvious reasons. In addition to whose future, there is also the question of where the future resides. One problem is that even though the future is always active in even the most mundane of decisions, expectations, and stories about the future are not always immediately obvious or easy to discern. They may be articulated, yet cloaked in statements, texts, or material representations (e.g. prototypes). Expectations show up in

both highly local, specific repertoires (e.g. in business projections, accounting schemes, project descriptions) and broader promises regarding the movement of technology in general (e.g. in government funding proposals, industry reports, or promotional materials for university education). Expectations are manifested diversely as scenarios of use, broader comprehensive visions, socio-technical scenarios, and expectations of techno-economic potentials (Borup and Konrad 2004). This variability suggests that, while expectations may sometimes be linked to particular actors, shared expectations quickly become depersonalized and, as they travel more widely, take on a more mythic quality that is less tethered to technical practices or identifiable actors.

Stories of the future are rambunctious and flexibly interpretable. They are local and global. They are implicit and explicit. This then becomes a methodological problem for scholars hoping to analyze the future. Where does the expectation begin and end? What becomes of agency amidst distributed and variable futures? If visions of the future are crucial to innovation and indeed to the co-production of technology and society, how can scholars study and perhaps even modulate expectations?

There are many approaches to these problems. Constructive and 'real-time' technology assessments (Guston and Sarewitz 2002; Rip et al. 1995) share the goal of constructing deliberate reflection to cope wisely with rapidly changing and seemingly open-ended environments. Real-time technology assessment does this through a suite of methodologies ranging from public values mapping, surveys, bibliometric studies, citizen forums, and lab ethnographies. The focus on anticipation involves developing scenarios to serve as inputs for both social-scientific analysis and public deliberation (Bennett 2008). Constructive technology assessment also focuses on anticipatory knowledge by developing multi-leveled scenarios with industrial and scientific actors with the goal of making more accountable and effective the nanotechnology innovation system (Rip 2005). In addition to these American and Dutch approaches, the Danish government pursued a Green Technology Foresight project focused on analyzing path creation in nanotechnology drawing from interviews, an interactive mail survey, and a mapping exercise (Andersen and Rasmussen 2006). In 2006, the Flemish government began a project that means to both add social context to scientific views on the future of nanotechnology and increase public awareness of nanotechnology (Goorden et al. 2008). The EU's Nanologue project was similarly tasked with facilitating the development of public engagement scenarios of the future of nanotechnology (Türk 2008). What is particular about these projects is the focus on early public engagement, the use of methodologies that have nuanced relation to futures, and the attempts to allow NSE researchers to characterize the outcomes of their knowledge production.

Each foresight project employs methods that hold within particular epistemological departures that specify not only what counts as anticipatory

knowledge, but also the proper channels from which to generate and share such knowledge. For instance, Delphi studies, like the one conducted by Salamanca-Buentello et al. (2005) to study the top ten nanotechnologies to benefit the developing world give primacy to expert knowledge, thus privileging anticipatory knowledge that has been developed through extensive formalized training and accreditation, which is supposed to lend objectivity. Other methods afford the layman the final word, thus respecting subjective experience and familiarity with the issues at hand. How time is conceived also varies. For instance, forecasting assumes that the future will be like the past, trend analysis assumes linearity, and horizon scanning reads the future in the present. Foresight's methods of inquiry, including the selection of knowledge indicators, can thus be seen as heavily conditioned and diverse.

While these speculative projects are often premised on the importance of recognizing the divergent pathways of the future in which current decisions are played out, there is nonetheless an outcome that is often prescriptive. Scenario planning typically results in two to five visions (Sharpe and van der Heijden 2007), horizon scanning focuses attention on particular indicators, and models significantly constrict which variables matter (Oreskes et al. 1994). There is always a movement from open-ended complexity to simplicity. Regardless of which methodology is employed, there is a radical constriction of variables. This reduction is a function of methodological choices just as much as a function of the subject under scrutiny. Foresight methods come into play to systematically discipline and analyze the representations of the future and in doing so create new meanings out of wide and broad possibilities. In this sense, future-oriented inquiries inevitably have a normative angle of projecting desirable (or undesirable) futures and thus are practices that both deconstruct and construct futures.

Disciplining representations of the future is neither innocent nor inconsequential. The results of foresight exercises and social science research about nanotechnology are effectively thrown back into the macro discourse, thus becoming players in the debates about the future potential of nanotechnology. And although there is no way to eliminate bias, there are ways to be careful.

Tensions of the future tense

There are many tensions in the future that plague foresight methodologies and STS studies that focus on the future. The ontological indeterminacy of the future means that it is not possible to know the future because we are always actively creating and re-creating multiple futures, any one of which may (or may not) actually emerge. The near indeterminacy of the future suggests a need to find ways to address and cope with uncertainty, rather than to seek to eliminate it. The aim is to better handle uncertainty in conditions of complexity, technological promises and rapid change. Yet,

this handling of uncertainty is by no means removed from the problems of proof and establishing legitimacy nor can it obliterate history. Methodological troubles abound.

Since we cannot deal with truth and credibility when it comes to different representations of the future, how can we handle reasonable questions of assessing right and wrong? Sociologic studies of expectations have shown that even in the absence of proof, futured-oriented testimony maintains some semblance of legitimacy. The simple act of attaching oneself to the short or long term is an act of affiliation and in the field of nanotechnology gets interpreted as alignment with 'serious' science or with science fiction (Selin 2007). Some visions have power; others don't. Such a distribution of authority begs the question of the political nature of promises, hope, and hype and forces an inquiry into how futures are legitimated.

In scenario planning communities, legitimacy is had, in part, by the cooperative construction of scenarios. That is, while there are many scenario planning practices that construct visions of the future behind a desk, the gold standard to achieve legitimacy in most practices involves the users of the scenarios – often the decision makers or policy makers – constructing their own scenarios. Those expected to make use of the scenarios are tasked with authoring them in attempts to muster buy-in through a sense of ownership. This lesson is also applied in the open source style scenario planning practiced by the Center for Nanotechnology in Society, where different communities (scientists, policy makers, social scientists, and publics) are expected to elaborate, critique, and develop scenarios based on preliminary vetted scenes (Selin 2008). What is right or wrong is not the say of the practitioner, but of the participants of the exercise.

There is a different measure of legitimacy in the social sciences. While foresight practitioners must question the efficacy of their work, social scientists have another host of questions about quality. Neutrality is cherished; transparency matters, and care must be taken to ensure that even though the results are not repeatable, the process is. Dealing with futures research – examining the things, words, and deeds maintaining a future orientation – requires a critical eye that bears temporality and power in mind. Social scientists as practitioners have the additional role to question who's legitimating what, to look into questions of winners and losers, and to become curious about what's being bought, sold, and traded in the future tense. Following the example of Dupuy and Grinbaum (2004), social scientists should study 'the linguistic and cognitive channels through which descriptions of the future are made, transmitted, conveyed, received and made sense of' (p. 17). Social scientists should tend to the cultural, political, and economic conditions from which future studies arise. What these visions articulate, how they do so, and to what effect are all ripe for inquiry. I venture that social scientists have more value not as futurists per

say but as scholars seriously interested in the future and responsible for asking how is it constructed, by whom, through what means, and with what consequences.

The trick is that STS scholars and other social scientists are often asked to become something akin to futurists or, at least, foresight practitioners. STS scholars have long argued that if technologies are part of the public space; exert influence in economics, religion, and culture; and shape societal interactions in new ways, they should be subject to early, participatory assessment. And in 2003, Winner and Baird argued to Congress that new technologies, like nanotechnology, should be scrutinized during the research and development phase to ensure that beneficial societal outcomes are maximized while negative consequences are kept to a minimum (Public Law 108–153; Bennett and Sarewitz 2006). Yet, such scrutiny immediately throws social scientists into and at the future and in the center of politics.

While NSE is a concrete practice in laboratories (whether of the physicist, the biologist, the mechanical engineer, or the chemist), it is simultaneously simulated virtually all the while maintaining another identity that holds out all the promise and perils of the next industrial revolution. Nanotechnology has come to represent the new frontier of science, with endless possibilities for future applications and discoveries, able to attract funding and attention on the one hand, and evoke naked protests about intensified inequality and the poisoning of our planet on the other. Nanotechnology is not a stable object, nor a completed project, but instead is (perhaps permanently) in the process of becoming. Until the technological processes are perfected, the artifacts designed and built and marketed, until consumers accept or reject – processes that are ongoing – most signifiers of the technology lie in the realm of fiction. While these processes unfold, there are various discursive ways in which nanotechnology is ordered as it moves around in different contexts and most of them evoke potential, futures and scenarios. Most of them rely on a pervasive optimism of the future.

Since the future of nanotechnology – and indeed the future of anything given a long enough time horizon – is disputable, volatile, and corruptible, there are risks in such investigations. In this context of races to colonize the future, social scientists need to keep a critical eye outward and inward. Such a state of affairs leads Williams to warn STS scholars to 'be skeptical about claims regarding the character and implications of technology' (2006, 327) and careful not to be co-opted by the decision-making processes within which they are working. It is important to be aware what is at stake in representing and analyzing the future in one way rather than another. Without evidence of what the future holds in 5, 10, 20 years, uncertainty and malleability give way to politics.

These are not idle considerations, just as speculation about nanotechnology is not idle but active, shaping, and constructive. The future is a

rhetorical and symbolic space to work out 'what is nanotechnology', but also serves a more productive role that underlies quotidian decision-making, alliance building, and resource allocation. Potentiality is shifted and revised based on the agendas, interests, and needs of those engaged in the space. This counts for what the scientists, media, politicians, and publics say as well as for the social scientists. Both as a rhetorical and blatant theoretical chartering of nanotechnology, potentiality is used and manipulated by various actors to gain and lose allies, muster authority, and to legitimate projects. Whether as a legitimating or destabilizing discourse, the future is a discourse with effects.

The sociology of the future

Despite the contrary and turbulent evolving road to development evidenced in STS research, optimistic expectations of unadulterated benefits to society or dystopic scenarios almost always accompany new technologies. Most new technologies are and have been accompanied by visions of use and – often exaggerated – benefits and risks (Corn 1986; Sturken et al. 2004). We should expect some speculation to orient the production and application of new knowledge (Nightingale 1998). Innovation often deals with unchartered territory. The dilemma is not that end results are imagined and articulated or that priorities are based on guesses of future application, but rather that technological expectations are too easily left unarticulated or dismissed yet are a potent component of innovation and the shape of things to come.

What is taking form is a sociology of the future comprised of scholars who are particularly interested in the future tense and how the future – as temporal abstraction, as story, as discursive strategy – is a component of social reality. Such work has evidenced how futuristic stories attending new technologies, the promises made, and the future benefits specified, all contribute to or detract from the success, strength, and efficacy of the resources poured into an innovation. The expectations, hopes, fears, and promises of new technologies are not set apart from, nor layered on top of scientific and technological practices, but are, rather, formative elements of innovation and of the constitution of a new field like nanotechnology.

Now, nothing is more fascinating than the future. Emergence has come to characterize social life, from talk of networks to urbanization to technology. Innocence of command and control has been forfeited in support of spontaneities, interconnectedness, and surprise. The past has been colonized, the present is fleeting, and the future holds all the mystery of lore. Stories of the future proliferate, promising at least, that things will be different. We are hopeful about new technologies, perhaps more than we trust new technologies. We have a 'long standing euphoria about technological advance' indebted to a 'heavily ritualized optimism' (Winner 2003, 124). 'Progress' is not questioned. Even when reality serves as a

corrective to our fantasy life, we still maintain hope for psychological comfort, to get things done, to rationalize decisions, or to avoid the alternatives. The future tense holds our hopes and fears in tension for us, so that we can go about our business of living in the present, though not without risks.

The sociology of the future is an emerging field of inquiry that works to understand future consciousness drawing from a mix of STS and the practice of foresight. Through an exploration of theories, methodologies, and quagmires of anticipation, this piece has introduced the field and suggested some ways the field is taking definition. Exploring the future tense provides a means of taking responsibility for what is to come; yet, the movement of the social sciences into the tricky terrain of the future presents challenges. Understanding plausibility, how different communities anticipate, and the performative role of expectations remain areas of research rich with dilemmas and delights. As social scientists begin to weave their own accounts of futures, attention should be paid to the politics of such rendering.

Short Biography

Cynthia Selin is an assistant research professor at the Center for Nanotechnology in Society at Arizona State University. She holds a doctorate in Knowledge and Management from Copenhagen Business School's Institute for Management, Politics and Philosophy. Selin's dissertation, entitled *Volatile Visions: Transactions in Anticipatory Knowledge*, explores three interwoven research areas – foresight methodologies, the sociology of expectations, and the emergence of nanotechnology. Her current research revolves around the tensions of the future tense and emerging technologies. Dr. Selin has published in *Science, Technology and Human Values*, *Futures*, and *Time & Society* with recent chapters in the *Handbook for Science, Technology and Society* (MIT Press 2007) and *Scenarios for Success: Turning Insight to Action* (Wiley 2007).

Notes

⋆ Correspondence address: Center for Nanotechnology in Society/Consortium for Science, Policy and Outcomes, Aizona State University, PO Box 874401, Tempe, AZ 85287-4401, USA. E-mail: cynthia.selin@asu.edu

[1] The term 'sociology of the future' has been used before notably in Bell and Mau's 1971 edited collection and more recently by Barbara Adam (2005).

References

Adam, B. 2000. 'Foreword.' Pp. xii–xiii in *Contested Futures: A Sociology of Prospective Techno-Science*, edited by N. Brown, B. Rappert and Webster, A. Aldershot, UK: Ashgate.

Adam, B. 2004a. 'Memory of Futures.' *KronoScope* **42**: 297–315.

Adam, B. 2004b. *Time*. Cambridge, MA: Polity Press.

Adam, B. 2005. 'Futures in the Making: Contemporary Practices and Sociological Challenges.' Paper presented at the *ASA conference, Philadelphia, PA. 1–17*. Last accessed March 24, 2006 from http://www.cf.ac.uk/socsi/futures/conf_ba_asa230905.pdf

Adam, B. 2006. 'Futurescapes: Challenges for Social and Management Sciences. Retroscapes and Futurescapes: Temporal Tensions in Organizations.' International conference. Palazzo d'Aumale, Terransin June.

Adam, B. and C. Groves 2007. *Future Matters: Action, Knowledge, Ethics*. Leiden, The Netherlands: Brill.

Akrich, M. 1992. 'The De-Scription of Technical Objects.' Pp. 205–24 in *Shaping Technology/Building Society: Studies in Sociotechnical Change*, edited by W. Bijker and J. Law. Boston, MA: Massachusetts Institute of Technology.

Andersen, M. M. and B. Rasmussen 2006. 'Nanotechnology Development in Denmark: Environmental Opportunities and Risk.' *Risoe R Report* 1550-EN.

Barben, D., E. Fisher, C. Selin and D. Guston 2007. 'Anticipatory Governance of Nanotechnology: Foresight, Engagement, and Integration.' Pp. 979–1000 in *The Handbook of Science and Technology Studies*, 3rd edn, edited by E. Hackett, O. Amsterdamska, M. Lynch and J. Wajcman. Cambridge, MA: MIT Press.

Beck, U. 1992. *The Risk Society: Towards a New Modernity*. London: Sage.

Bell, W. 1997. *Foundations of Futures Studies: Human Science for a New Era*. New Brunswick, NJ: Transaction Publishers.

Bennett, I. 2008. 'Developing Plausible Nano-Enabled Products.' Pp. 149–55 in *Yearbook for Nanotechnology in Society: Presenting Nanotechnological Futures*. edited by E. Fisher, C. Selin and J. Wetmore. Berlin, Germany: Springer.

Bennett, I. and D. Sarewitz 2006. 'Too Little, Too Late?: Research Policies on the Societal Implications of Nanotechnology in the United States.' *Science as Culture* **15** (4): 309–26.

Berne, R. 2006. *Nanotalk: Conversations with Scientists and Engineers about Ethics, Meaning, and Belief in the Development of Nanotechnology*. Mahwah, NJ: Lawrence Erlbaum Associates.

Bijker, W. E. 1994. *Of Bicycles, Bakelites, and Bulbs: Toward a Theory of Sociotechnical Change*. Cambridge, MA: MIT Press.

Bijker, W. B., T. P. Hughes and T. J. Pinch (eds) 1987. *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*. Cambridge, MA: MIT Press.

Bloomfield, B. P. and T. Vurdubakis 1995. 'Disrupted Boundaries: New Reproductive Technologies and the Language of Anxiety and Expectation.' *Social Studies of Science* **25**: 533–51.

Borup, M. and K. Konrad 2004. *Expectations in Nanotechnology and in Energy: Foresight in the Sea of Expectations*. Background Paper, Research Workshop on Expectations in Science & Technology, April 29–30. Denmark: Risoe National Laboratory.

Brown, N. and M. Michael 2003. 'A Sociology of Expectations: Retrospecting Prospects and Prospecting Retrospects.' *Technology Analysis and Strategic Management* **151**: 3–18.

Brown, N., B. Rappert and A. Webster (eds) 2000. *Contested Futures: A Sociology of Prospective Techno-Science*. Aldershot: Ashgate.

Callon, M. 1995. 'Four Models of the Dynamics of Science.' Pp. 29–63 in *Handbook of Science and Technology Studies*, edited by S. Jasanoff, G. E. Markle, J. C. Peterson and T. Pinch. London, UK: Sage.

Carlson, W. B. and M. Gorman 1992. 'The Cognitive Process of Invention: Bell, Edison, and the Telephone.' Pp. 48–79 in *The Inventive Mind: Creativity in Technology*, edited by D. Perkins and R. Weber. New York, NY: Oxford University Press.

Chia, R. 2004. 'Re-educating Attention: What Is Foresight and How Is It Cultivated?' Pp. 21–37 in *Managing the Future: Foresight in the Knowledge Economy*, edited by H. Tsoukas and J. Shepard. Malden, MA: Blackwell.

City of Berkeley Community Environmental Advorsory Commission 2006. Manufactured Nanoparticle Health and Safety Disclosure Report. December 5.

Corn, J. J. 1986. *Imagining Tomorrow: History, Technology and the American Future*. Cambridge, MA: MIT Press.

Drexler, E. K. 1986. *Engines of Creation: The Coming Era of Nanotechnology*. New York, NY: Doubleday.

Dublin, M. 1991. *Futurehype: The Tyranny of Prophecy*. New York, NY: Dutton.

Dupont. 2005. 'DuPont, Environmental Defense Create Framework for Nanotechnology.' *DuPont News*, October 12. www2.dupont.com/Media_Center/en_US/daily_news/october/article20051012b.

Dupuy, J. P. and A. Grinbaum 2004. 'Living with Uncertainty: Toward the Ongoing Normative Assessment of Nanotechnology.' *Techne: Research in Philosophy and Technology* **83**: 4–25.
ETC Group 2003. *The Big Down: From Genomes to Atoms*. Winnipeg: Action Group on Erosion, Technology and Concentration.
Feynman, R. 1959. 'There's Plenty of Room at the Bottom.' Talk given at the annual meeting of the American Physical Society at Caltech.
Fujimura, J. 2003. 'Future Imaginaries: Genome Scientists as Socio-Cultural Entrepreneurs.' Pp. 176–99 in *Genetic Nature/Culture: Anthropology and Science Beyond the Two Culture Divide*, edited by A. Goodman, D. Heath and S. Lindee. Berkeley, CA: University of California Press.
Geels, F. and G. Smit 2000. 'Failed Technology Futures: Pitfalls and Lessons from a Historical Survey.' *Futures* **329**: 867–85.
Goorden, L., M. van Oudheusden, J. Evers and M. Deblonde 2008. 'Nanotechnologies for Tomorrow's Society: A Case for Reflexive Action Research in Flanders, Belgium.' Pp. 163–82 in *Yearbook for Nanotechnology in Society: Presenting Nanotechnological Futures*, edited by E. Fisher, C. Selin and J. Wetmore. Springer.
Grupp, H. and H. A. Linstone 1999. 'National Technology Foresight Activities Around the Globe: Resurrection and New Paradigms.' *Technological Forecasting & Social Change* **60**: 85–94.
Guston, D. H. and D. Sarewitz 2002. 'Real-time Technology Assessment.' *Technology in Culture* **24**: 93–109.
Hackett, E., O. Amsterdamska, M. Lynch and J. Wajcman (eds) 2007. *The Handbook of Science and Technology Studies*, 3rd edn. Cambridge, MA: MIT Press.
Hayles, K. N. (ed.) 2004. *Nanoculture: Implications of the New Technoscience*. Portland, OR: Intellect Books.
Hedgecoe, A. and P. Martin 2003. 'The Drugs Don't Work: Expectations and the Shaping of Pharmacogenetics.' *Social Studies of Science* **333**: 327–64.
Irvine, J. and B. Martin 1984. *Foresight in Science: Picking the Winners*. London: Frances Pinter.
Jasanoff, S., G. E. Markle, J. C. Peterson and T. Pinch (eds) 1995. *Handbook of Science and Technology Studies*. London, UK: Sage.
Losch, A. 2006. 'Means of Communicating Innovations: A Case Study for the Analysis and Assessment of Nanotechnology's Futuristic Visions.' *Science, Technology and Innovation Studies* **2**: 103–25.
MacDonald, C. 2004. 'Nanotechnology, Privacy and Shifting Social Conventions.' *Health Law Review* **123**: 37–40.
Macnaughten, P., M. Kearnes and B. Wynne 2005. 'Nanotechnology, Governance, and Public Deliberation: What Role for the Social Sciences?' *Science Communication* **272**: 268–91.
Meridian Institute 2005. *Nanotechnology and the Poor: Opportunities and Risks*. Last accessed March 24, 2006, from http://www.meridian-nano.org/NanoandPoor-NoGraphics.pdf
Merton, R. K. 1948. 'The Self-fulfilling Prophecy.' *The Antioch Review* **8**: 193–210.
Milburn, C. 2004. 'Nanotechnology in the Age of Posthuman Engineering: Science Fiction as Science.' Pp. 109–29 in *Nanoculture: Implications of the New Technoscience*, edited by N. K. Hayles. Bristol, UK: Intellect Books.
Mnyusiwalla, A., A. Daar and P. Singer 2003. 'Mind the Gap: Science and Ethics in Nanotechnology.' *Nanotechnology* **14**: R9–13.
Nanologue 2007. 'Europe-wide Dialogue on the Ethical, Social and Legal Impacts of Nanotechnology.' Available: www http://www.nanologue.net/
Nightingale, P. 1998. 'A Cognitive Model of Innovation.' *Research Policy* **277**: 689–709.
Oberdörster, E. 2004. 'Manufactured Nanomaterials (Fullerenes, C60) Induce Oxidative Stress in the Brain of Juvenile Largemouth Bass.' *Environmental Health Perspectives* **112**: 1058–62.
Oreskes, N., K. Shrader-Frechette and K. Belitz 1994. 'Verification, Validation, and Confirmation of Numerical-models in the Earth-sciences.' *Science* **263** (5147): 641–6.
Ringland, G. 1998. *Scenario Planning: Managing for the Future*. Chichester, UK: John Wiley & Sons.
Rip, A., 2005. 'Technology Assessment as Part of the Co-Evolution of Nanotechnology and Society: the Thrust of the TA Program in NanoNed.' *Nanotechnology in Science, Economy and Society*. Marburg, January 13–15.
Rip, A. and H. te Kulve 2008. 'Constructive Technology Assessment: Supporting Reflexive Co-evolution through Socio-technical Scenarios.' Pp. 49–70 in *Yearbook for Nanotechnology in*

Society: Presenting Nanotechnological Futures, edited by E. Fisher, C. Selin and J. Wetmore. Berlin, Germany: Springer.
Rip, A., T. Misa and J. Schot (eds) 1995. *Managing Technology in Society: The Approach of Constructive Technology Assessment*. London, UK: Pinter Publishers.
Roco, M. and W. S. Brainbridge 2001. *Subcommittee on Nanoscale Science Engineering and Technology: Societal Implications of Nanoscience and Nanotechnology*. Dordrecht, The Netherlands: Kluwer Academic Publishers.
Rosenberg, N. 1976. 'On Technological Expectations.' *Economic Journal* **86** (343): 523–35.
Salamanca-Buentello, F., D. L. Persad, E. B. Court, D. K. Martin, A. S. Daar et al. 2005. 'Nanotechnology and the Developing World.' *PLoS Med* **25**: e97.
Sarewitz, D., R. A. Pielke and R. Byerly (eds) 2000. *Prediction: Science, Decision Making and the Future of Nature*. Washington, DC: Island Press.
Schot, J. and A. Rip 1997. 'The Past and Future of Constructive Technology Assessment.' *Technological Forecasting and Social Change* **54**: 251–68.
Selin, C. 2006. *Volatile Visions: Transactions in Anticipatory Knowledge*. PhD dissertation. Copenhagen, Denmark: Samfundsliteratur.
Selin, C. 2007. 'Expectations and the Emergence of Nanotechnology.' *Science, Technology and Human Values* **322**: 196–220.
Selin, C. 2008. 'Negotiating Plausibility.' *Science and Engineering Ethics*. Forthcoming.
Sharpe, B. and K. van der Heijden 2007. *Scenarios for Success: Turning Insights in to Action*. Chichester, UK: John Wiley & Sons, Ltd.
Slaughter, R. 1998. 'Futures Beyond Dystopia.' *Futures* **30**: 993–1002.
Slaughter, R. 2005. *The Knowledge Base of Future Studies*, professional edn. Brisbane: Foresight International, CD-ROM.
Smith, M. R. and L. Marx 1994. *Does Technology Drive History? The Dilemma of Technological Determinism*. Cambridge, MA: MIT Press.
Stengers, I. 2000. *The Invention of Modern Science*. Minneapolis, MN: University of Minnesota Press.
Sturken, M., D. Thomas and S. J. Ball-Rokeach (eds) 2004. *Technological Visions: The Hopes and Fears that Shape New Technologies*. Philadelphia, PA: Temple University Press.
Tenner, E. 2001. 'Unintended Consequences and Nanotechnology.' Pp. 241–5 in *Social Implications of Nanoscience and Nanotechnology* edited by M. C. Roco and W. S. Bainbridge. Arlington, VA: National Science Foundation.
Tsoukas, H. and J. Sheperd (eds) 2004. *Managing the Future: Foresight in the Knowledge Economy*. Malden, MA: Blackwell.
Türk, V. 2008. 'Nanologue.' Pp. 117–22 in *Yearbook for Nanotechnology in Society: Presenting Nanotechnological Futures*, edited by E. Fisher, C. Selin and J. Wetmore. Berlin, Germany: Springer.
Van der Heijden, K. 2004. *Scenarios: The Art of Strategic Conversation*. Chichester, UK: John Wiley & Sons.
Van Lente, H. 1993. *Promising Technology: The Dynamics of Expectations in Technological Developments*. PhD Thesis. Twente: Universitet Twente.
Van Lente, H. and A. Rip 1998. 'The Rise of Membrane Technology: From Rhetorics to Social Reality.' *Social Studies of Science* **282**: 221–54.
Van Merkerk, R. O. and H. van Lente 2005. 'Tracing Emerging Irreversibilities in Emerging Technologies: The Case of Nanotubes.' *Technological Forecasting & Social Change* **72**: 1094–111.
Wack, P. 1984. 'Scenarios: The Gentle Art of Re-perceiving: A Thing or Two Learned While Developing Planning Scenarios for Royal Dutch/Shell.' *Harvard Business School Working Paper. Division of Research, Harvard Business School*: 1–77.
Williams, R. 2006. 'Compressed Foresight and Narrative Bias: Pitfalls in Assessing High Technology Futures.' *Science as Culture* **154**: 327–48.
Winner, L. 1977. *Autonomous Technology: Technics-out-of-Control as a Theme in Political Thought*. Cambridge, MA: MIT Press.
Winner, L. 2003. Testimony of Langdon Winner, House Committee on Science.
Wood, S., R. Jones and A. Geldart 2003. *The Social and Economic Challenges of Nanotechnology*. Swindon: Economic and Social Research Council.

